International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 3, Issue 11, November 2014

A GPRS-Based Wearable Physiological Parameters Identification Using Smartphone

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***Abstract*-This project represents an remote monitoring system to reduce the potential risks for Sudden Infant Death Syndrome (SIDS), which can be used at home or in hospitals. This system consists of blood pressure, temperature sensor and heart rate sensor. The heart rate concentration in the exhaled pulse, temperature and heart rate is regularly and frequently sensed. It also includes a GPRS module to transmit the data. Besides the alarm signal, all sensor signals are multiplexed and transmitted along with the infant's ID for diagnosis purposes. The transmitter is in sleeping mode until there is an initiation from PIC controller. The alarm signal of each infant is the ID designated for the incubator. At the receiver end, an SMS will be received as soon as alarm signal is sent by the identified transmitter while the server starts to record the data and the doctor is informed via a mobile.**

***Keywords:*GPRS, ECG, Java, Android, Embedded, SMS, Alarm signal.**

I. INTRODUCTION

The three sensors with their leads are placed on the appropriate locations of the patient. The ECG signals detected from the patient are of very low amplitude are amplified by the instrumentation amplifier of sufficient gain .These ECG voltage signals are amplified, filtered and then compared with fixed threshold (reference voltage) to detect a ECG event. This detected event is indicated by LCD & Buzzer.There is a level detector section which gives the state of the QRS complex of the heart.ECG is detected for some period oftime and an audio visual alarm system will sound indicating rate is below 60bpm and also another section of the system detectstachycardia if the heart rate is above 120bpm.These ECG signals are being interfaced or transmitted through GPRS and anandroid to PCand Tablet or Mobile phone respectively using microcontroller. The microcontroller captures the biosignals, processes it and sends it to the GPRS.

The GPRS then establishes connectivity with the PC or the Android GPRS and the signals thus are transmitted to the PC or the Tablet. The android application can be installed and tested on any smart phone or tablet and screen resolution can be adjusted later as per requirement. This helps the doctor to have visual description of the patient ECG without the need of mounted monitors.

There were some proposed remote monitoring systems, such as cardiopulmonary monitoring [4-7], vision monitoring [8], oxygen consumption monitoring [9] and multi-purpose monitoring [10]. Some approaches are invasive [4-7, 9-10], making both the infant and his/her parents uncomfortable. Some are not as effective as expected such as baby monitoring cameras due to the unrecognized signs of SIDS [8].

We propose a new method using heart rate sensors, temperature sensor, and heart beat sensor placed in the crib around an infant to non-invasively monitor the exhaled air concentration, temperature, and heart beat variation from him/her. By monitoring the outputs of heart rate sensors, we can detect if there is anything wrong with the infant's respiration. The output data can be used to activate an alarm or logged for further diagnoses. With GPRS integration, our system can be used to monitor a large number of infants in the nursery room of a hospital.

ISSN: 2278 – 909X

II.METHODOLOGY

A.Electrocardiogram(ECG)Signals

Electricalwaves causetheheartmuscletopump. Thesewavespassthroughthebodyandcanbemeasured at electrodes (electrical contacts) attached to the skin. Electrodesondifferentsidesoftheheartmeasuretheactivity ofdifferent partsoftheheartmuscle. AnECGdisplays the voltagebetween pairs oftheseelectrodes, calledLeads, and themuscleactivitythattheymeasure,from different directions. Forexample, BipolarLimbLeadIrepresents the voltagebetween the(positive) leftarm(LA)electrode and rightarm (RA)electrode. SoLeadI=LA–RA.Thisdisplay indicates theoverallrhythmoftheheart,andweaknessesin differentpartsofthe heart muscle.[7]

TheECGsignalcanbedividedintoseveralparts, each witha specifictimeintervalanda specialsignificance andrepresentation.ECGwaveformcomponents,asillustrated inFig.2,are:

1. Pwave:Depolarizationoftherightandleftatria.

2. QRS complex: Right and left ventricular depolarization. Thenormaldurationis0.06to0.10 seconds.

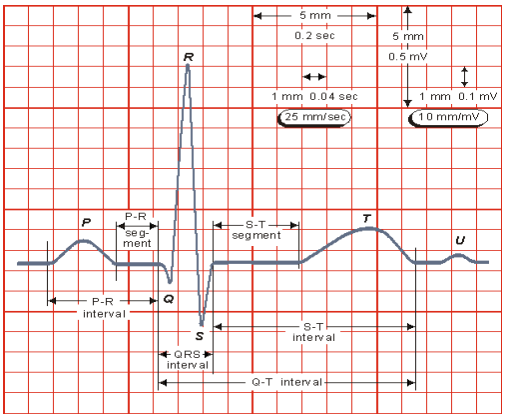
3. Twave:Ventricularrepolarization.

4. Uwave: Laterepolarizationofpapillarymuscles.

5. PR interval: Time interval from onset ofatrial depolarization (Pwave)toonsetofventricular depolarization (QRScomplex).ThenormalP-R intervalis0.12to0.20seconds.

6. QTinterval:Durationofventricular depolarization andrepolarization. Inmostcases,theQ-Tinterval lastsbetween0.34and0.42seconds.

III .NORMAL ECG WAVEFORM



A. System design

Crib design

Infants may take various sleeping positions and theexhaled air may spread in many directions due to aircirculation. Thus, an array of heart rate sensors is placed aroundthe crib on the bars to provide sufficient information. Acircuit board connected to the sensors is placed outside thecrib to process the data. The circuit board includes awireless module for transmitting and receiving data. Themodule is away from the infant to ease parents' concern ofelectromagnetic waves from the wireless module. A drasticvariation of concentration will produce an abruptchange in sensor outputs and the processor will be activatedto send out an alarm signal. With the GPRS approach, anidentification (ID) signal of the infant will be sent out tocorrelate the sensing/alarm signals with the ID. This willsignificantly reduce the labour costs and time. The sensor data and ID can be pulled periodically for monitoring and calibration. The stored vital sign data can help doctors to identify or diagnose any potential health problems in infants.

System Overview

Fig. 2 shows the functional block diagram of the system hardware. The system has been designed to take several inputs to measure physiological parameters of human such as temperature, heart rate, pressure, and detection of any fall. The inputs from the sensors are integrated and processed by the PIC controller. The results are

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sent through GPRS module as SMS to the physician.

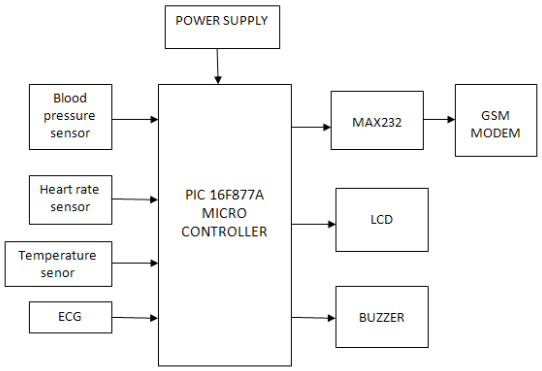

Fig. 1 block diagram

Hardware for Mobile:

Fig.2 block diagram

The sensors mounted in the crib will send the signals to the PIC controller which is programmed. If any ofthe values become abnormal the system provides the alarm and sends SMS via GSM modem to the physician. The GPRS is interfaced with PIC by using serial communication driver MAX 232. The LCD is placed to continuously monitor the infant.

IV.BLOOD PRESSURE SENSOR

Blood pressure (**BP**), sometimes referred to as **arterial blood pressure**, is the pressure exerted by circulating blood upon the walls of blood vessels, and is one of the principal vital signs. When used without further specification, "blood pressure" usually refers to the arterial pressure of the systemic circulation, usually measured at a person's upper arm. A person's blood pressure is usually expressed in terms of the systolic pressure over diastolic pressure and is measured in millimeters of mercury (mm Hg). Normal resting blood pressure for an adult is approximately 120/80 mm Hg.

Blood pressure varies depending on situation, activity, and disease states, and is regulated by the nervous and endocrine systems. Blood pressure that is pathologically low is called hypotension, and pressure that is pathologically high is hypertension. Both have many causes and can range from mild to severe, with both acute and chronic forms. Chronic hypertension is a risk factor for many complications, including peripheral vascular disease, heart attack, and stroke. Hypertension is generally more common, also due to the demands of modern lifestyles. Hypertension and hypotension go often undetected because of infrequent monitoring.

V. PIC MICROCONTROLLER

The **16F877A is one of the most popular PIC** microcontrollers and it's easy to see why - it comes in a 40 pin DIP pinout and it has many internal peripherals. The only disadvantage that you could level at it is that it does not have an internal clock source like most of the other more modern PIC's. There is an alternative part 16F887/A that has nearly the same functionality as the 16F887A but also includes an internal clock like the 16F88 and 18F4550 plus it has nanowatt technology.

VI. HEART RATE SENSOR AND TEMPERATURE UNIT

It consists of LED (light emitting diode) and LDR (lightdetection resistor) which are placed parallel to each other. LEDemits IR (Infrared) rays so that, when the finger is placed inbetween LED and LDR so that there exists some systolicpressure [15, 16]. LED emits IR rays which are travelled throughfinger and blood flows with arteriole pressure. Wheneversystolic pressure is applied, normal pressure of blood flow isdisturbed at fingertip which is high and IR rays penetratethrough blood and are received by LDR. The signals are analogwhich are converted into digital by the PIC. LM35 temperature sensor [17] isused to measure the temperature and connected to PIC. Thissensor unit works under low power DC input of 5V which iscontrolled by a mini transformer.

VII. MAX232

Since GPRS supports digital data transmission,MAX232 is used to convert the digital data in the serial formusing parallel-in-serial-out shift registers suitable for wireless communication. UART IC chip allows the digital datatransmission in the form of bits (bits per second) inasynchronous manner (characters transmission). RS232standards are used for serial communication [18], which are notTTL (Transistor-Transistor-Logic) compatible.

VIII. GPRS

GPRS is abbreviated as General Packet Radio Service [19]. GPRS modem has a slot for inserting SIM(Subscriber Identity Module). GSM

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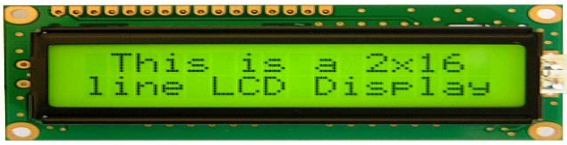
network contains MobileStation, Base station subsystem and Network subsystem. Mobilestation contains IMEI number and SIM has IMSI number. Basestation subsystem contains Base Transceiver Station which hasantennas for communication and Base Station Controller whichcontrols multiple base stations. Network subsystem containsVLR (Visitor Location Register), HLR (Home LocationRegister), AuC (Authentication Center) and EIR (EquipmentIdentity Register). MSC (Mobile Switching Center) is the majorpart which is the gate way for communication between mobilestation and PSTN. HLR stores the information about thesubscriber and the current location of subscriber. VLR providesthe services to the subscribers of HLR who are visitor users.AUC gives the security of the user and to identify the locationof the subscriber. EIR is also for security purpose and toidentify the mobile station. MAX232 is connected to GPRS modem so that it is useful for serial data transmission.OSS(Operation Support System) is used to control the traffic ofusers.

IX. LCD DISPLAY



X. THE PROPOSEDECG CIRCUIT

Theproposed systemshouldmeetthefollowingengineering requirements: Intheproposed ECGcircuit,themaingoalwasto minimize thesizeofthecircuitandminimizethenumberof electrodesneededwithoutcompromising theaccuracyofthe measurement.Thecircuitispoweredwitha DCpowersupply (18Vbatteries).Asapreamplifier,andtoobtainLeadI= LA-RA,ahighprecisioninstrumentationamplifierAD624 [8] wasused.Thebandwidth waslimitedto(8.8-40Hz)usinga high passfilteroffirstorderandthelow passfilterofsecond order.Thebandwidthandtheordersofthefiltersaredeci ded uponafterexperiment andtrialstofinallycomeupwiththe clearest ECGsignal takenfrom onlytwosurface electrodes placedonthethumbs.

Theproposed ECGcircuit isdivided intofivemain partseachofadifferent roleandsignificance asillustrated in theblockdiagramofFig.3.First,thesurfaceelectrodes used are disposableadhesivepre-jellifiedelectrodesattachedtothe leftandright thumbs toacquire theLA andRA of LeadIto beanalyzedlatertoobtainthe heartrateofthepatient. Second,weusedtheAD624which isahighprecision, low noise,instrumentation amplifierdesignedprimarilyforuse withlowleveltransducers,includingloadcells,strainga uges andpressuretransducers. Anoutstanding combinationoflow noise,highgainaccuracy,lowgaintemperature coefficient andhighlinearitymakethe AD624idealforuseinhigh resolution dataacquisition systems.Anactivefirstorder Butterworth highpassfilteristhenplacedtoremovelow frequencynoise;itisdesignedtohaveacutofffrequency of 8.84Hz.Also,anactivesecondorderButterworth lowpass filterisplacedtoremovehighfrequency noise;itisdesigned tohaveacutofffrequency of40Hz.Thegainamplifier amplifying theECGsignalamplitudebytentimesaccording tothisequation:V(out)=(1+Rf/Rin)*[V(in)]. So, V(out)=10*[V(in)]. TheproposedECGcircuitaimsto optimize thecircuitandreduceittominimal sizewithout decreasing theaccuracy oftheECGsignalandthus calculating thecorrectheartrate.TheQuadLM348Nisused insteadof3IC's.Itconsistsoffourindependent, high-gain, internallycompensated,lowpoweroperationalamplifi ers.

XII.SYSTEM DESIGN

A.AndroidSmartphoneAppli cation:

AndroidisaLinux-basedoperating systemfor mobiledevices suchassmartphones andtabletcomputers. It isdeveloped bytheOpenHandsetAlliance ledbyGoogle. The Android software has been chosen in the proposed mobileheartratemonitoroverothersoftware stacksfor mobiles due to its open sources and the Android SDK (SoftwareDevelopmentKit) whichprovidesthe tools and APIs necessarytobegin developingapplicationsfrom scratch ontheAndroidplatform usingtheJavaprogramming language. Fig.5illustrates thelayoutofthesmartphone application developedfortheaccessory. WhereasFig.6 describes theflowchartofthecodewrittenfortheAndroid baseddeviceapplication.

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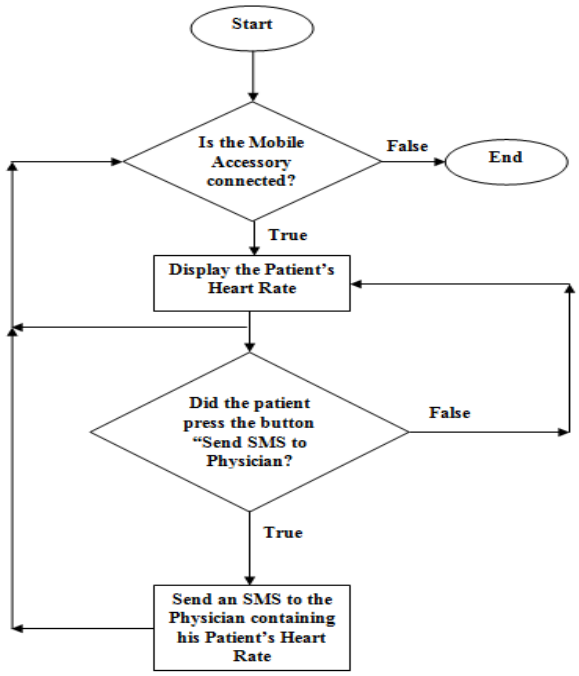
Fig.5LayoutoftheAndroidSmartphoneApplication



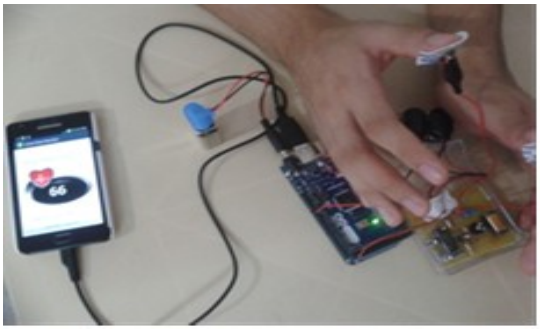


Fig.9HeartRateofa patientdisplayedonthephone application

XIII.RESULT AND DISCUSSION

Heart rate sensorand LM35sensor senses the heart rate, temperature, exhaled blood pressure of infant by taking the average of ten readings byfixing maximum and minimum values (normal range of heart beat is 60-150bpm and 98.6° F) and the data is transferred to PIC controller. Crystal oscillator generates 11.0952MHz of signals usedfor operation and by enable input MUC works, stores the data inEPROM chip which is displayed on LCD. PIC stores thedigital data after converting the analog data from sensor unitby ADC in the PIC, for some delay unit of time and resets the reading in PIC as well as in LCD also. MAX232 receives the digitaldata and converts into serial form suitable for GPRScommunication so that data is received by the user (doctor) byverifying the IMEI number.The doctor advises precautions forthe temporary observation of the patient from serious condition.

1. Initializing and resetting all components

2.DisplayHeartrate/BP/Temp

3. Displaying the abnormality

4. After sending the SMS to the Doctor/a person it will display as 'SMS sent' on the LCD display

XIV. CONCLUSION AND FUTURE SCOPE

By using this prototype circuit containing PIC16F877,GPRS Modem, LCD and other hardware circuit so that the pagemessages can be transferred at fixed time intervals to thecorresponding medical expert to give necessary precautions totake care about the patient. This system has the following features: i. PIC16F877 consumes low power with suitabledevices for interconnection. ii. Auto alarm system is providedwhich sounds only when the reading

ISSN: 2278 – 909X

exceeds or reduces thanthe normal level. iii. Continuous monitoring of patients is donewhich is simple by using GPRS network.

The final concept of the system by themselves was positive and also have continuously encouraged this development is implemented in a practical way and continuity as a project. It is noteworthy that the idea of this work is to show the possibility of having a useful solution, low cost, using the existing infrastructure in telecommunications technologies at the site of interest and the use of free software tools for applicationdevelopment. A first approach would be the Caribbean Region of the Colombian territory. The next job is to consist pilots from different parts of the region, allowing different rural populations enjoy timely medical care and lower cost.

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ISSN: 2278 – 909X